

20/ppts

**DESCRIPTION****A HANDOVER CONTROL METHOD AND A SYSTEM THEREWITH****TECHNICAL FIELD**

5           The present invention relates to a control  
system that controls a mobile station in mobile  
communications, typically cellular phone  
communications, and specifically relates to the  
control of a mobile station when it switches base  
10 stations that the mobile station is communicating  
with, i.e., relates to the system which performs  
handover.

**BACKGROUND TECHNOLOGY**

15           In the mobile communications, such as  
cellular phone communications, the control of  
switching of radio base stations to communicate with  
in response to the movement of a mobile station,  
i.e., handover, is indispensable. Fig.21 shows a  
20 conventional system that realizes handover. The  
system includes a mobile station 30, two or more  
radio base stations (here, a case with two radio  
base stations is shown) 21 and 22, and an RNC (Radio  
Network Controller: radio network control unit) 10.  
25 The RNC 10 includes an electric field intensity  
measurement control unit 11 and the radio resources  
management unit 12 and a switch 13.

Next, Fig.22 shows the flow of the  
handover operation. The mobile station 30 is  
30 connected to a backbone network through the radio  
base station 1 (21) and the switch 13, and  
communicates through this backbone network with  
terminals that belong to the Internet, the PSTN

(Public Switched Telephone Network) and the ISDN (Integrated Service Digital Network) which are operated by communication carriers other than the mobile communication carrier that manages the backbone network. When the mobile station 30 moves away from the radio base station 1 (21) and approaches the radio base station 2 (22), the electric field intensity from the radio base station 1 (21) becomes weaker, and, conversely, the electric field intensity from the radio base station 2 (22) becomes stronger. Since the electric field intensity measurement control unit 11 requires the mobile station 30 to measure and report the electric field intensities of nearby radio base stations including the radio base station 1 (21) (S1 of the operation flow), the mobile station 30 measures the electric field intensities of two or more radio base stations around itself, and transmits the information to the electric field intensity measurement control unit 11 through the radio base station 1 (21) on the communication line (S2 and S3 of the operation flow). The electric field intensity measurement control unit 11 informs the radio resources management unit 12 that handover will take place, when the electric field intensity of the radio base station 2 (22) becomes higher than the electric field intensity of the radio base station 1 (21) (S4 of the operation flow).

The radio resource management unit 12 controls radio resources required for communication between the mobile station and the radio base station. So to speak, radio resources are physical parameters, types of which are dependent on multiple

accessing methods and duplexing methods that are  
used by a radio system. Specifically, in FDMA  
(Frequency Division Multiple Access), it is the  
bandwidth of a carrier wave, and the appropriated  
5 time length of the carrier wave to a certain  
communication, and, in TDMA (Time Division Multiple  
Access), it is the bandwidth of the carrier wave,  
and a number of time slots that are slices in a  
fixed interval of an appropriated time of the  
10 carrier wave. Further, in the case of CDMA (Code  
Division Multiple Access), it is the bandwidth, and  
transmission electric power density of the carrier  
wave, which is dependent on the spread factor. The  
maximum values of these values are determined by the  
15 maximum transmission capacity of each radio base  
station and a mobile station.

The radio resource management unit which  
manages radio resources such as above assigns the  
amount of radio resources equivalent to the radio  
20 resources which were being assigned to the radio  
base station 1 (21) to the radio base station 2 (22),  
in order to communicate with the mobile station 30,  
and sets up a new radio channel (S5 of the operation  
flow). That is, even if the communicating  
25 counterpart of the mobile station 30 is switched  
from the radio base station 1 (21) to the radio base  
station 2 (22), the transmission capacity of the  
mobile station 30 and the radio base station does  
not change. However, when an amount of the radio  
30 resources equivalent to prior to the switching was  
not available (S6 of the operation flow), or the  
electric field intensity of the radio channel newly  
set up was insufficient and not suitable for

communication (S8 of the operation flow), re-selection of radio resources, or handover is suspended (S11 of the operation flow).

Simultaneously, the radio resources management unit  
5 12 controls the switch 13, and switches the connection between the backbone and the radio base station 1 (21) to the connection between the backbone and the radio base station 2 (22) (S9 of the operation flow). Further, the radio resources  
10 management unit 12 controls the mobile station 30 through the radio base station 1 (21) so as to switch the communicating counterpart from the radio base station 1 (21) to the radio base station 2 (22) (S10 of the operation flow). Since the switching  
15 control is performed synchronously, there is almost no communication interruption during the handover.

The control procedure mentioned above is called Mobile-Assisted Handover and used by PDC (Personal Digital Cellular Telecommunication System).  
20 Explanation of this procedure is detailed in "Personal Digital Cellular Telecommunication System ARIB Standard RCR STD-27H edition", published by Association of Radio Industries and Businesses.

As mentioned above, in the conventional  
25 handover system, the handover is triggered by monitoring and checking the electric field intensity or the amount of radio wave interference. For this reason, in conventional systems, the handover is not triggered when an amount of traffic which goes via a  
30 specific radio base station increases because of increase in the user's data volume of the mobile station 30. For this reason, a problem occurs that the radio resources of the radio base station run

short, and the available communication bandwidth decreases. Although the communication itself can be secured in such a system that offers the packet telecommunication service which communicates user information in packets only when the user data to be transmitted is generated, for example, PDC-P (PDC mobile packet communications Systems) even if the radio resources run short, a sharp fall in a throughput is caused and there is a possibility of producing an inconvenience to the user. Further, it has been difficult to efficiently utilize radio resources of a mobile communications network as a whole by making a mobile station to communicate with another radio base station that has a margin in the radio resources, when the shortage of radio resources of a certain radio base station takes place.

Further, a minimum bandwidth guarantee type IP (Internet Protocol) communication service which guarantees only the minimum of a throughput is currently offered as a cheap communication service in a wired communications network. However, in the conventional mobile communications, since there was a possibility of causing the sharp fall in the throughput by the increase in traffic as mentioned above, it was difficult to apply such bandwidth guarantee service to mobile communications.

Further, conventionally, handover systems have been proposed (for example, JP, 2000-175243) to cope with a traffic congestion condition in the communication of a radio base station by switching a mobile station from the station with which the communication has been made to an adjacent radio



secure a level of communication service quality desired by a user as much as possible, when the radio base station experiences the traffic congestion.

5           The purpose of the present invention is served by the handover control method that detects an inability to communicate with a predetermined minimum bandwidth secured of any mobile stations in motion that are communicating with the radio base station, and switches the communicating counterpart of the mobile station that communicates with the radio base station mentioned above from the radio base station to another radio base station among handover control methods that switch a radio base station serving as the communicating counterpart of a mobile station.

10           In the handover control method, the communicating counterpart of the mobile station that communicates with the base station is switched to another radio base station when a communication securing the predetermined minimum bandwidth becomes impossible at any mobile stations in communication with the radio base station.

20           The mobile station whose radio base station serving as the communicating counterpart is to be switched may be the mobile station that has become incapable of communicating under a condition that secures the above-mentioned minimum bandwidth or any of other mobile stations. Further, the number of the mobile stations whose radio base station serving as the communicating counterpart is to be switched may be one or more.

          Depending on the amount of radio resources





communication in a mobile station is shared by the plurality of the radio base stations.

The plurality of the radio base stations switched as communicating counterparts of the mobile stations which communicate with the above-mentioned radio base station may also include the above-mentioned radio base station which was communicating with the mobile station concerned, before switching.

From a view point that it is desirable to switch the communicating counterpart of a mobile station to a radio base station whose electric field intensity becomes higher, a structure can be such that a radio base station that provides the highest electric field intensity and the mobile station that receives the signal, excepting the combination of the mobile station and the radio base station that are currently communicating, are selected as the mobile station and the radio base station for the communicating counterpart as the object of the handover, based on the information relative to the electric field intensity of the radio base station acquired from each mobile station in each handover control method mentioned above.

From a view point that it is desirable that the mobile station whose communication bandwidth is below a standard is switched as much as possible to the radio base station which has a sufficient radio resource available, a structure can be such that a mobile station that has the radio resources allocation the closest to the minimum bandwidth, having no allowance to increase in the user data volume, and a radio base station that has the largest amount of the radio resources available

are selected as the mobile station and the radio base station for the handover.

From a similar perspective, a structure can be such that a mobile station whose minimum  
5 bandwidth is the largest and that requires the radio resources, and a radio base station that has the largest amount of the radio resources available are selected as the mobile station and the radio base station for the handover.

10 From a viewpoint of offering a specific technique for detecting an inability to communicate with the minimum bandwidth secured, the detection of the inability to communicate with the minimum  
15 bandwidth secured between mobile stations and the base station can be performed based on measuring results by measuring one or a combination of the electric field intensity, a bit error rate, a frame error rate, and a packet discard rate.

Further, the mobile station mentioned  
20 above can choose the radio base station which serves as a communicating counterpart after switching mentioned above. The radio base station which serves as the communicating counterpart after the above-mentioned switching may also be selected in a node  
25 other than the above-mentioned mobile station, the information relative to the selected radio base station is notified to the mobile station concerned from the node concerned, and the radio base station which serves as a communicating counterpart of the  
30 mobile station concerned can be switched to the notified radio base station.

From a viewpoint of enabling handover between radio communication systems which adopt



5 In such a handover control method, if a  
decision is made that the communication of a radio  
base station is in a traffic congestion condition, a  
combination of any mobile stations that communicate  
with the base station concerned and one or more  
radio base stations that can communicate with the  
mobile stations is selected in accordance with a  
predetermined standard. In addition, the  
communicating counterpart of the mobile stations in  
10 the selected combination is switched to one or more  
radio base stations in the combination.

15 The number of combinations of the mobile  
station and one or more radio base stations to be  
selected can be singular or plural. Further the  
mobile station concerned and the above-mentioned  
radio base station which performs the on-going  
communication can also be included in the plurality  
of the radio base stations.

20 The traffic congestion condition in the  
above-mentioned radio base station can be determined  
based on various information such as an available  
amount of the radio resources of the radio base  
station concerned, radio resources amount that the  
mobile station that will communicate with the radio  
25 base station concerned will use, an error rate in  
the communication, and whether or not the  
communication is being performed with the  
predetermined minimum bandwidth.

30 From a viewpoint that the communicating  
counterpart of a mobile station can be switched to  
the radio base station that has a margin in the  
radio resources as much as possible, a structure can  
be such that the predetermined standard for

selecting the combination of the above-mentioned mobile station and a radio base station is defined by the available amount of the radio resources of the radio base station or the required amount of the radio resources.

From a viewpoint that the communicating counterpart of a mobile station can be switched to a radio base station with a better communication condition as much as possible, the predetermined standard for selecting the combination of the above-mentioned mobile station and a radio base station can be defined based on the receiving electric field intensity in communication between a mobile station and a radio base station.

From a viewpoint that the communicating counterpart of the mobile station whose required data communication volume is not satisfied can be switched as often as possible, the predetermined standard for selecting the combination of the above-mentioned mobile station and a radio base station can be defined based on a ratio of the amount of radio resources permitted to the mobile station to the amount of radio resources currently used in fact.

From a viewpoint that the switching of the communicating counterpart of a mobile station is easy, the predetermined standard for selecting the combination of the above-mentioned mobile station and a radio base station can be defined based on the number of the radio base stations with which a mobile station should perform simultaneous communications after switching the communicating counterpart.

In such a handover control method, the

communicating counterpart of a mobile station can be switched with a priority to a fewer number of radio base stations, for example. In this case, the switching to a fewer number of radio base stations  
5 can be performed comparatively easily.

From a viewpoint that the radio base station handling the on-going communication can be included in the radio base station to which the switching is to be performed as much as possible as  
10 a communicating counterpart for the mobile station after the switching, the predetermined standard for selecting the combination of the above-mentioned mobile station and a radio base station can be defined based on whether or not to include the radio  
15 base station handling the on-going communication as the radio base station to communicate after the switching of the communicating counterpart of the mobile station.

In the above-mentioned handover control  
20 method, a structure can be such that a priority is attached to the combinations of each mobile station that communicates with the radio base station concerned and one or more of the radio base station concerned and its adjacent radio base stations,  
25 thereby selecting a combination of a mobile station and a radio base station that has a higher priority.

The above-mentioned priority is the ranking about the appropriateness of a mobile station and a radio base station communicating  
30 mutually, and it can be, but is not limited to be, expressed by a mark given in accordance with the predetermined standard or it may be expressed by the ranking itself. That is, the combination of the

mobile station and radio base station where a priority is the higher means that it is the more suitable for communicating. "Suitable for communicating" means that a better quality communication can be carried out under a satisfactory condition, and that the control required for handover can be performed easily.

From a viewpoint that a handover process can be performed centrally, a structure can be such that, relative to the handover control method mentioned above, the process for selecting a combination of any mobile station that communicates with the radio base station concerned and one or more radio base stations with which the mobile station concerned can communicate is performed in a node connected with each radio base station via a wired section.

From a viewpoint that a process about handover can be performed in a distributed fashion, a structure can be such that, relative to the handover control method mentioned above, the mobile station communicating with the radio base station concerned performs the process in which it chooses a combination of the mobile station concerned and one or more radio base stations with which a communication is possible in accordance with the above-mentioned predetermined standard.

Further, in the above-mentioned handover control method, a structure can be such that the above-mentioned mobile station which communicates with the radio base station concerned determines whether the radio base station concerned is in a traffic congestion condition.

From a viewpoint that the communication of a mobile station is maintained reliably in high quality, the handover control method mentioned above can be structured such that when the communication condition between the mobile station and one or more radio base stations is supervised and the supervised communication condition is in a condition worse than a predetermined standard condition, after switching the communicating counterpart of the above-mentioned mobile station to the one or more radio base stations mentioned above, switching of the communicating counterpart of the mobile station concerned may be performed once again.

In such a handover control method, when the communication condition between the mobile station and the radio base station after the switching is worse than a predetermined condition after switching the communicating counterpart of a mobile station, the communicating counterpart of the mobile station is switched again. In this manner, the mobile station concerned can ensure communication in the better condition.

In the above-mentioned handover control method, a structure can be such that an error rate of the communication between a mobile station and one or more radio base stations is supervised as the communication condition mentioned above.

Further, the above-mentioned purpose in the handover control system that switches a radio base station serving as the communicating counterpart of a mobile station is served by a detection means for detecting that the communication with the predetermined minimum bandwidth secured



becomes impossible at any of mobile stations communicating with the radio base station, and a switching means for switching the communicating counterpart of the mobile station communicating with the above-mentioned radio base station from the radio base station concerned to another radio base station when the detection means detects that any mobile station becomes incapable of communicating with the predetermined minimum bandwidth secured.

10 Further, the purpose of the present invention described above in the handover control system that switches a radio base station serving as the communicating counterpart of a mobile station is served by a detection means for detecting that the communication with the predetermined minimum bandwidth secured becomes impossible at any of mobile stations communicating with the radio base station, and a switching means for switching the communicating counterpart of the mobile station communicating with the above-mentioned radio base station from the radio base station concerned to a plurality of other radio base stations when the detection means detects that any mobile station becomes incapable of communicating with the predetermined minimum bandwidth secured.

Further, the purpose of the present invention described above in the handover control system that switches a radio base station serving as the communicating counterpart of a mobile station is served by a handover system that includes a traffic congestion checking means for checking whether or not the communication traffic in the radio base station becomes congested, a selection means for

selecting a combination of a mobile station communicating with the radio base station concerned and one or more radio base stations that are capable of communicating with the mobile station concerned  
5 according to a predetermined standard when the traffic congestion checking means determines that the communication traffic of the radio base station is congested, and a switching control means for switching the communicating counterpart of the  
10 mobile station in the combination selected to one or more radio base stations in the combinations that are selected.

In addition, other purposes, features, and advantages of the present invention are clarified by  
15 detailed explanation in the following with reference to appended drawings.

#### **BRIEF EXPLANATION OF THE DRAWINGS**

Fig. 1 is a block diagram showing the  
20 first example of the handover system of the present invention.

Fig. 2 shows the operation flow of the handover system of the present invention.

Fig. 3 is a block diagram showing the  
25 second example of the handover system of the present invention.

Fig. 4 shows an example of structure of a signal splitting / combining unit of the present invention.

30 Fig. 5 shows the operation flow of the second example of the present invention.

Fig. 6 is a block diagram showing the third example of the handover system of the present

invention.

Fig. 7 shows the operation flow of the third example of the present invention.

Fig. 8 is a block diagram showing the fourth example of the handover system of the present invention.

Fig. 9 shows an example of structure of a mobile communications system to which the fifth example of the handover system of the present invention is applied.

Fig. 10 is a block diagram showing the fifth example of the handover system of the present invention.

Fig. 11 is a sequence drawing showing an example of the procedure of a handover process.

Fig. 12 is a sequence drawing showing an example of the process procedure for selecting the optimum mobile station and a radio base station.

Fig. 13 shows an example (No. 1) of an evaluation point table.

Fig. 14 shows an example (No. 2) of an evaluation point table.

Fig. 15 shows an example (No. 3) of an evaluation point table.

Fig. 16 shows an example of a management table for an evaluation point.

Fig. 17 is a sequence drawing showing an example of the process procedure for selecting the optimum mobile station and a radio base station in the sixth example of the handover system of the present invention.

Fig. 18 is a flowchart which shows an example of the process procedure for selecting the

optimum mobile station and a radio base station in the seventh example of the handover system of the present invention.

Fig. 19 is a block diagram showing the eighth example of the handover system of the present invention.

Fig. 20 is a sequence drawing showing an example of the procedure of handover process.

Fig. 21 is a block diagram showing a conventional example.

Fig. 22 shows the operation flow of the conventional example.

#### THE BEST MODE IMPLEMENTATION OF THE INVENTION

Hereafter, embodiments of the present invention will be described based on the drawings.

Fig. 1 is the block diagram showing the first example of the handover system concerning the implementation mode of the present invention.

This system includes mobile stations (here 1 and 2) 31 and 32, two or more radio base stations (here 1 and 2) 21 and 22, and an RNC 10. The RNC 10 includes a minimum bandwidth guarantee unit 14, an electric field intensity measurement control unit 11, radio resources management unit 12, and a switch 13.

Fig. 2 shows the operation flow of this system. First, the mobile station 1 (31) and the mobile station 2 (32) shall communicate with different terminals in the Internet, PSTN and ISDN through the radio base station 1 (21), the switch 13, and a backbone. A description will be made as to the case where data volume of the user of the mobile station 1 (31) increases, and the radio base station



1 (31) in this description) and a radio base station  
(the radio base station 2 (22) in this description)  
for carrying out the handover. As selection methods,

(1) a method to choose a radio station  
5 that gives the highest electric field intensity, and  
the mobile station which received this, based on the  
electric field intensity information on the radio  
base station obtained from each mobile station  
through the electric field intensity measurement  
10 control unit 11,

(2) a method to choose a mobile station  
with an allocation of radio resources the closest to  
the minimum bandwidth, and a radio base station in  
which the radio resources is left the most based on  
15 the radio resources management information,

(3) a method to choose a mobile station  
whose value of the minimum bandwidth is large and  
needs a large amount of the radio resources, and a  
radio base station that has the largest amount of  
20 the radio resources available,  
and the like are possible. Further, a set of the  
plurality of the methods may be used. Further, radio  
resources is assigned to the radio base station 2  
(22) so that the radio resources of which amount may  
25 not be less than the minimum value of the amount of  
radio resources defined by the minimum bandwidth  
guarantee unit 14 to this radio base station,  
setting up a new radio channel (S6 of the operation  
flow). Next, the electric field intensity  
30 measurement control unit 11 directs the mobile  
station 1 (31) to supervise whether the newly set-up  
radio channel is suitable for communication via the  
radio base station 1 (21) (S7 of the operation flow).

If suitable for communication, the electric field intensity measurement control unit 11 directs execution of the handover to the radio resources management unit 12. The radio resource management unit 12 controls the switch 13, and switches the connection between the backbone and the radio base station 1 (21) to the connection between the backbone and the radio base station 2 (22) (S9 of the operation flow). Further, the radio resources management unit 12 controls the radio base station 1 (21), the radio base station 2 (22), and the mobile station 1 (31) to switch the communicating party of the communication of the mobile station from the radio base station 1 (21) to the radio base station 2 (22) completely (S10 of a work flow). These switching actions are performed synchronously.

In addition, this handover system is also equipped with functions to supervise a fall in the electric field intensity, an occurrence of radio wave interference and an occurrence of fading in performing the handover as in conventional systems.

Fig. 3 shows the second example of the handover system concerning the implementation mode of the present invention. In this system, when  
neither the radio base station 1(21) nor the radio  
base station 2 (22) can singly provide a sufficient  
radio resource, the minimum bandwidth is secured by  
communicating with both the radio base station 1  
(21) and the radio base station 2 (22) by adding up  
the data transmission capacity of both  
communications. When it still runs short, the third  
and fourth radio base stations will be selected, and  
the minimum bandwidth is guaranteed by communicating

with a number of radio base stations. The system of the present invention includes the mobile stations (here 1 and 2) 31 and 32, two or more radio base stations (here 1 and 2) 21 and 22, and the RNC 10.

5 The RNC 10 includes the minimum bandwidth guarantee unit 14, the signal splitting / combining unit 15, the electric field intensity measurement control unit 11, the radio resources management unit 12, and the switch 13. The example of the signal splitting /  
10 combining unit 15 is shown in Fig. 4. In the unit, circuits are divided into the upstream circuit and the downstream circuit. Signals are input to the upstream circuit from the base station and to the downstream circuit from an exchange. These signals  
15 are divided into signals for every radio base station in the case of the downstream signal and for every mobile station in the case of the upstream signal by the distribution units 151, 152, 161, and 162. The distributed signal is compounded and  
20 outputted by the combining units 153, 154, 163, and 164 according to the sequence of transmission at the transmitting source.

On the other hand, the mobile station compliant with this system is equipped with two or more transceiver units for communicating with two or more radio base stations, and signal splitting / combining units for distributing user information to two or more transceiver units. In addition, the structure of the signal splitting / combining unit may be obtained by eliminating the combiner in the upstream circuit and the splitter in the downstream circuit, and further using one input terminal on the upstream side and one output terminal on the



downstream side in reference with Fig. 4 presented above.

Fig. 5 shows the operation flow. When it is determined that the minimum bandwidth desired by a user is not satisfied (S4 of flow of operation), the radio resources management unit 12 chooses a plurality of mobile stations and radio base stations for which handover is to take place (S5 of the operation flow). As specific selection methods, the method of giving priority to combinations where a high electric field intensity of the radio base station is measured by the mobile stations, the method of giving priority to combinations that leave more room of the radio resources, and the method that combines these methods are possible. Next, the radio resources management unit 12 assigns radio resources so that the minimum bandwidth which the mobile station 1 (31) needs may be satisfied, and a new radio channel may be set up relative to the selected mobile station 1 (31) and selected two or more radio base station (S6 of the operation flow). Next, the electric field intensity measurement control unit 11 directs the mobile station 1 (31) to measure the electric field intensity and report the result in order to determine whether the radio channel which the radio resources management unit 12 newly set up is suitable for communication. If the electric field intensity measurement unit 12 determines that the newly set up channel is suitable for communication, it directs the radio resources management unit 12 to carry out handover. The radio resource management unit 12 controls the splitting / combining unit 15, splitting and combining signals

for each mobile station (S9 of the operation flow).  
Further, the radio resources management unit 12  
controls the switch 13, switching the signal for  
every mobile station, and sends out this signal to  
5 the Internet or the like through the backbone (S10  
of the operation flow).

Fig. 6 shows the third example which added  
the bandwidth measuring unit 16 that supervises  
whether the minimum bandwidth of each user and each  
10 communication service is secured to the handover  
system mentioned above. Fig. 7 shows the operation  
flow. In the system of the present invention, the  
bandwidth measuring unit 16 may be installed, for  
example, between the switch 13 and the backbone to  
15 measure throughput of each user and all or any of  
the communication services (S12 of the operation  
flow). Specifically, as for the information signal  
which has a frame structure, each frame has an error  
detection function. For this function, CRC (Cyclic  
20 Redundancy Control) which adds a redundant code may  
be used, for example. The throughput in unit time is  
obtained using this facility by disregarding frames  
if a frame error is detected where, for example,  
there is no retransmission performed. Further, when  
25 the measurement result shows non-fulfillment of the  
minimum bandwidth (S13 of the operation flow), the  
minimum bandwidth guarantee unit 14 re-assigns radio  
resources and a new radio channel is set up.

Fig. 8 shows the fourth example where a  
30 handover system is applied to a handover between  
systems that use different communication protocols  
for the radio transmission path. Structure of this  
system includes a system 2 that has a similar

structure to conventional examples and performs equivalent operations, and a system 1 that has the system 2 under itself and that has the radio transmission path of a different communication protocol from the system 2. As an example of this case, the system 1 may correspond to IMT-2000 and the system 2 may correspond to PDC.

The system 1 includes the mobile stations (here 1 and 2) 31 and 32, two or more radio base stations (here 1 and 2) 21 and 22, and the RNC 10. The RNC 10 includes the minimum bandwidth guarantee unit 14, protocol converters 17 and 18, the electric field intensity measurement control unit 11, the radio resources management unit 12, and the switch 13.

In this system, the switch 13 of the system 1 and a switch 103 of the system 2 are connected through the protocol converter 17. Further, the minimum bandwidth guarantee unit 14 of the system 1 and the radio resources management unit 102 of the system 2 are also connected through the protocol converter 18. Here, the communication protocols of the radio transmission path in this system differ in the system 1 and the system 2. Therefore, in order that a mobile station complies with the communication protocol of both systems, it is equipped with a transceiver unit for the system 1, and a transceiver unit for the system 2. Further, it also has a switch that switches the two transceiver units by control from the system 1 or the system 2.

Although operation of this system is almost equal to the contents of the operation described in the first example mentioned above, it

differs in that the minimum bandwidth guarantee unit 14 communicates with the radio resources management unit 102 of a system 2 via the protocol converter 18. Further, the radio resources management unit 12 of the system 1 and the radio resources management unit 102 of the system 2 exchange information with each other via the protocol converter 18 when adjusting between the two for assignment of radio resources.

Further, the fifth example of the handover system concerning the implementation mode of the present invention will be described. In this fifth example, when a radio base station experiences a traffic congestion condition, mobile stations suitable for handover to adjacent base stations will be selected from mobile stations which are communicating with the radio station, and the selected mobile stations are handed-over to the adjacent radio base stations.

The mobile communications system to which the handover system relative to this fifth example is applied is structured as shown in Fig. 9.

In Fig. 9, radio base stations BS1, BS2, and BS3 are connected to the RNC 10, and the RNC 10 is connected to the backbone. By such structure, each of the mobile stations MS1 through MS5 which are located in the communication area of each of the radio base stations BS1, BS2, and BS3 can communicate with terminals in PSTN (Public Switched Telephone Network), ISDN (Integrated Service Digital Network), the Internet, and the like through the radio base stations BS1, BS2, BS3, the RNC 10 and the backbone. While this fifth example illustrates the structure with five mobile stations MS1 through

MS5 communicating with the three radio base stations BS1, BS2, and BS3, this is an example and is not specifically limited to it.

The handover system as mentioned above  
5 applied to the mobile communications systems is structured as shown in Fig. 10.

In Fig. 10, the RNC 10 has the electric field intensity measurement control unit 11, the radio resources management unit 12, and the switch  
10 13 like the example mentioned above. Further, the RNC 10 is equipped with mobile station management unit 19. The mobile station management unit 19 evaluates combinations of each mobile station and each radio base station which should communicate  
15 with each of the mobile stations, using an evaluation point table that is predefined from viewpoints which are mentioned later, such as receiving electric field intensity and required radio resource. In addition, according to the  
20 evaluation result, an optimum combination of a mobile station and a radio base station for the handover is selected from the combinations of each mobile station and radio base stations.

A description will follow as regards the  
25 handover performed, for example, when the mobile station MS1 which communicates with the radio base station BS1 moves to the communication area of the radio base station BS2 from the communication area of the radio base station BS1, with reference to  
30 Figs. 9 and 10.

As shown in Fig. 9, the radio base station BS1 communicates with each of the mobile stations MS1 and MS5 which are currently in its communication

area, and the radio base station BS2 is communicating with each of the mobile stations MS2, MS3, and MS4 which are currently in its communication area. In specific reference to the mobile station MS1 and the mobile station MS2, the communication sequence is as shown in Fig. 11, for example.

As shown in Fig. 11 (a), where the mobile station MS1 communicates with the radio base station BS1, and the mobile station MS2 communicates with the radio base station BS2, measurement directions for the receiving electric field intensity are transmitted from the electric field intensity measurement control unit 11 in the RNC 10 to each of the mobile stations MS1 and MS2 through each of the radio base stations BS1 and BS2. According to the directions, each of the mobile stations MS1 and MS2 measures the electric field intensity from each of radio base stations which are currently in the vicinity, and report the measured values to the RNC 10 through the radio base stations BS1 and BS2.

The mobile station MS1 communicating with the radio base station BS1 moves to the communication area of the radio base station BS2. In that case, as shown in Fig. 11 (b), the measured value of the electric field intensity of the radio base station BS1 and the measured value of the electric field intensity of the radio base station BS2 which are reported to the electric field intensity measurement control unit 11 of the RNC 10 from the mobile station MS1 are compared. And if the electric field intensity from the radio base station BS2 is higher than the electric field intensity from

the radio base station BS1 by a predetermined amount,  
it triggers the RNC 10 to start the control for  
switching the communicating counterpart of the  
mobile station MS1 from the radio base station BS1  
5 to the radio base station BS2 (a handover) (handover  
1). However, the situation of the radio base station  
BS2 is that that a large amount of its radio  
resource is being used in this case by the  
communications with the mobile stations MS2, MS3,  
10 and MS4. If the radio base station BS2 determines  
that it will run short of the radio resources for  
newly assigning communication with the mobile  
station MS1 (traffic will be congested), a direction  
is made from the radio base station BS2 to the radio  
15 base station BS1 through the RNC 10 to suspend the  
handover of the mobile station MS1, and the  
direction is further transmitted to the mobile  
station MS1 from the radio base station BS1.

Thus, the mobile station MS1 which  
20 received the direction to suspend the handover  
maintains the communication condition with the radio  
base station BS1. As shown in Fig. 11 (c), in this  
condition, the radio base station BS2 reports to the  
RNC 10 that it is short of the radio resources. The  
25 RNC 10 which received this report performs process  
for selecting mobile stations which are suitable for  
handover to the adjacent radio base stations of each  
of the mobile stations MS2, MS3, and MS4 which are  
communicating with the radio base station BS2 in  
30 order to enable communication between the mobile  
station MS1 moving into the communication area of  
the radio base station BS2, and the radio base  
station BS2. Details of this process will be

described later.

When a combination of a mobile station which should carry out handover and a radio base station to which the handover should be carried out is selected, the radio base station in the combination is made to carry out the handover of the mobile station in the selected combination (handover 2). For example, when it is decided that the radio base stations BS2 and BS3 share the communication of the mobile station MS2 at which the handover is carried out (refer to the second example), a link is established between the mobile station MS2 and the radio base stations BS2 and BS3 by the handover processes (electric field intensity measurement and reporting, base station switching control, and the like) of the mobile station MS2. In addition, the mobile station MS2 performs radio communications with the radio mobile stations BS2 and BS3 in parallel, and further communicates with other communication terminals through the RNC 10 and the backbone.

Thus, if part of the radio resources which are needed for communication of the mobile station MS2 is shared by the radio base station BS3 (partial handover of the mobile station MS2), the radio resources for the mobile station MS1 moved to the communication area of the radio base station BS2 communicating with the radio base station BS2 can be secured. In this condition, the RNC 10 will resume the handover process of the mobile station MS1 suspended in the above (refer to (d) in Fig. 12). That is, the RNC 10 directs resumption of the base station switching control to each of the radio base



stations BS1 and BS2 and the mobile station MS1.  
Consequently, the communicating counterpart of the  
mobile station MS1 is switched from the radio base  
station BS1 to the radio base station BS2 (handover).

5 Henceforth, the mobile station MS1 communicates with  
other terminals through the radio base stations BS2,  
the RNC 10 and the backbone.

Thus, when the mobile station MS1 has  
moved to the communication area of the radio base  
station BS2, possibly causing a traffic congestion  
status at the radio base station BS2, the radio  
resources for communication between the mobile  
station MS1 and radio base station BS2 can be  
secured by making the adjacent radio base station  
15 BS3 carry out the handover (also including partial  
handover) of the mobile station which has already  
communicated with the radio base station BS2. In  
addition, by performing the above-mentioned process  
for other mobile stations in a chain reaction,  
20 reliable communication can be given to as many  
mobile stations as possible.

As mentioned above, in order to enable a  
communication between the mobile station MS1 moved  
to the communication area of the radio base station  
25 BS2, and the radio base station BS2 concerned, the  
selection process is performed to choose a mobile  
station suitable for handover to another adjacent  
radio base station out from the mobile stations MS2,  
MS3, and MS4 which are already in communication with  
30 the radio base station BS2 (referring to drawing 11  
(c)), process of which is made according to the  
procedure specifically shown in Fig. 12.

In Fig. 12, the electric field intensity





range of the received electric field in a mobile station is  $4\text{dB}\mu\text{V} - 64\text{dB}\mu\text{V}$ .

When the measured value  $P_{ij}$  of the received electric field from the radio base station  $BS_i$  (partner station) which is currently communicating with the mobile station  $MS_j$  becomes below the above-mentioned dynamic range, the evaluation point  $f(P_{ij})$  is "zero point" (the lowest point), and the evaluation point  $f(P_{ij})$  becomes the higher one by one like "one point", "two points", "three points", and "four points" as the measured value  $P_{ij}$  of the electric field intensity becomes the higher. Therefore, it indicates that the higher the evaluation point is for the combination of the mobile station  $MS_j$  and the radio base station  $BS_i$  which is the current communicating counterpart, the more desirable that the communication with this radio base station  $BS_i$  is maintained for the mobile station  $MS_j$ .

On the other hand, if the measured value  $P_{ij}$  of the received electric field from a radio base station (adjacent station)  $BS_i$  which is adjacent to the radio base station which is currently communicating with the mobile station  $MS_j$  becomes below the above-mentioned dynamic range, like the case of the radio base station (partner station) which serves as a communicating counterpart mentioned above, the above-mentioned evaluation point  $f(P_{ij})$  is "zero" (the minimum point), and the evaluation point  $f(P_{ij})$  becomes the higher one by one like "one point", "two points", "three points", and "four points" as the measured value  $P_{ij}$  of the electric field intensity becomes the higher.



evaluation point  $g_1 (r_j)$  is "four points" (the highest score) and the evaluation point  $g_1 (r_j)$  becomes the lower one by one like "three points", "two points", "one point", and "zero point" as the usage rate  $r_j$  becomes the larger. When the current traffic amount of the mobile station  $MS_j$  is small (the usage rate is small), it is considered that a probability is high for the small amount of the radio resources being available in an adjacent radio base station, and handover of the mobile station  $MS_j$  to the adjacent radio base station will be easy. Further, as the transmission speed becomes the higher (the amount of communications increasing), required transmission electric power becomes the larger, and it will be difficult for the mobile station  $MS_j$  to communicate with a distant radio base station. Therefore, the higher the evaluation point  $g_1 (r_j)$  is, it indicates a situation that the more it is suitable for carrying out the handover of the mobile station  $MS_j$  to the adjacent station.

When the usage rate  $R_i$  of the radio resources in the radio base station (partner station)  $BS_i$  which is performing the current communication with the mobile station becomes 0 - 20%, the evaluation points  $g_2 (R_i)$  is "four points" (the highest score), and the evaluation point  $g_2 (R_i)$  becomes the higher one by one like "one point", "two points", "three points", and "four points" as the usage rate  $R_i$  becomes the larger. Therefore, the higher the evaluation point  $g_2 (R_j)$  is, there is the more margin in the radio resources in the radio base station (partner station)  $BS_i$  which is communicating with the mobile station, indicating that the

combination of the mobile station and the radio base station  $BS_i$  is suitable for communication.

On the other hand, if the  $R_i$  of a radio base station (adjacent station)  $BS_i$  which is  
5 adjacent to the radio base station which is communicating with the mobile station also falls between 0% and 20%, the evaluation point  $g_2 (R_i)$  is "four points" (the highest score), and the evaluation point  $g_2 (R_i)$  becomes the smaller one by  
10 one like "three points", "two points", "one point", and "zero point" as the usage rate  $R_i$  becomes the larger. Therefore, the higher the evaluation point  $g_2 (R_i)$  is, the larger is the amount of the margin in the radio resources in the radio base station  $BS_i$   
15 which is adjacent to the radio base station communicating with the mobile station, and it indicates that the combination of the mobile station and the adjacent station  $BS_i$  is in a suitable situation for communication, i.e., it is desirable  
20 to handover the mobile station from the radio base station currently communicating to the adjacent radio base station.

When the margin amount of the radio resources is small in both the radio base station  
25 (partner station) and the radio base station (adjacent station) adjacent to the partner station serving as a communicating counterpart of a mobile station, there is a case where the mobile station may communicate by establishing links with a  
30 plurality of radio base stations. In consideration of this type of the situation, the mobile station management unit 19 evaluates combinations as mentioned above of a mobile station and a radio base

station, in addition, gives an evaluation point D about combinations of a mobile station and one or more radio base stations to be linked. The evaluation point D is defined based on an evaluation point table as shown in Fig. 15, for example.

As for a mobile station, it is desirable to maintain the ongoing communication with the radio base station as much as possible, and even if it is the case where the communicating counterpart of the mobile station is switched to other radio base stations, the number of the radio base stations for switching is desired to be as small as possible for ease of controlling and the like. From such a viewpoint, the evaluation point is defined as shown in Fig. 15.

In Fig. 15, when the mobile station maintains the communication with the radio base station (own station) with which a communication is ongoing, that is, a handover of the mobile station will not take place, the highest evaluation point of "five points" is given. In addition, the evaluation point becomes lower as the number of the radio base stations after switching the communicating counterpart of a mobile station increases. And where the communicating counterpart for the mobile station is switched to a plurality of radio base stations (two, three, and more than it), the evaluation point will be higher when the radio base station (own station) which is performing the current communication is included in the radio base stations after the switching than when it is not included.

The mobile station management unit 19 performs a process for selecting a combination of a



mobile station and a radio base station suitable for the mobile station for newly communicating after carrying out handover based on each evaluation point as mentioned above of the combinations of a mobile station and a radio base station. This process is performed as follows, for example.

First, an evaluation point  $y_{ij}$  about the mobile station  $MS_j$  communicating with the radio base station  $BS_j$  after handover, i.e., the evaluation point  $y_{ij}$  for the combination of the mobile station  $MS_j$  and the radio base station  $BS_i$ , using each evaluation points  $f(P_{ij})$ ,  $g_1(r_j)$  and  $g_2(R_i)$  mentioned above is calculated according to the formula presented below.

$$y_{ij} = \alpha f(P_{ij}) + \beta g_1(r_j) + \gamma g_2(R_i) \quad \text{--- (1)}$$

In the above-mentioned formula (1),  $\alpha$ ,  $\beta$ , and  $\gamma$  are weighting constants predefined based on required conditions of a system.

Further, a final evaluation point  $z$  for the combination of the mobile station  $MS_j$  and the radio base station  $i$  is calculated using the above-mentioned evaluation point  $D$  (refer to Fig. 15)

$$Z = y_{ij} + \epsilon D \quad \text{--- (2-1)}$$

And, for example, as shown in Fig. 16, each evaluation value which is calculated according to the above formula (2-1) is summarized in the management table format for each of the combinations of  $MS_2$ ,  $MS_3$  and  $MS_4$  that are communicating with the radio base station  $BS_2$  that will become congested,

and the mobile station MS1 that has entered into the communication area of the radio base station BS2 and the radio base stations BS2, BS1, BS3 and so on.

Further, the evaluation point z about the combination of the mobile station MS<sub>j</sub> and two radio base stations BS<sub>i1</sub> and BS<sub>i2</sub> and the combination of the mobile station MS<sub>j</sub> and three radio base stations BS<sub>i1</sub>, BS<sub>i2</sub>, and BS<sub>i3</sub> are calculated according to the formula in below, respectively.

$$z = (y_{i1j} + y_{i2j}) / 2 + \epsilon D \quad \text{-- (2-2)}$$
$$z = (y_{i1j} + y_{i2j} + y_{i3j}) / 3 + \epsilon D \quad \text{-- (2-3)}$$

In the above-mentioned formulae (2-2) and (2-3),  $\epsilon$  is a weighting constant. Further, each of the above-mentioned radio base stations BS<sub>i1</sub>, BS<sub>i2</sub>, and BS<sub>i3</sub> is selected in the descending order of the magnitude of the value  $y_{ij}$  that is calculated as above to the radio base station combined with the mobile station MS<sub>j</sub>.

The evaluation points z calculated as above for combinations of each mobile station MS<sub>j</sub> and a plurality (2 or 3) of the radio base stations are added to the management table as shown in Fig. 16.

When the management table is completed as mentioned above, the combination of the mobile station which should carry out handover and the radio base station of the handover destination will be selected with reference to the management table.

For example, with reference to the management table shown in Fig. 16, combinations of the mobile station BS<sub>j</sub> and the radio base station



radio base station BS2 increases or when a new mobile station start communication with the radio base station BS2, causing a shortage of the radio resources in the radio base station BS2.

5           Further, although the number of the combinations of the mobile stations and radio base stations which are selected was one in the example mentioned above, it is not limited to that. A plurality of combinations of mobile stations and radio base stations that become the communicating counterpart may be selected. In this case, the combinations are selected in the descending order of the evaluation point as mentioned above. The number of the combinations can be defined based on a relationship between an available amount of the radio resources in the radio base station, and the radio resources required by a mobile station which newly starts communication (by handover or a new call), and by a mobile station where the amount of data communications increased rapidly in the communication with the radio base station.

10           Further, the sixth example of the handover system concerning the implementation mode of the present invention will be described. In the sixth example, each mobile station autonomously switches the radio base station serving as the communicating counterpart (a handover) based on communication conditions. For this purpose, each mobile station has the similar function as the mobile station management unit 19 provided in the RNC 10 mentioned above.

15           In the sixth example of the handover system, a process is performed according to a

procedure as shown in Fig. 17, for example.

In Fig. 17, the radio resources management unit 12 of the RNC 10 requires a report about the availability (or usage) of radio resources from each of the radio base stations BS1, BS2, and BS3 (1). Each of the radio base stations BS1, BS2, and BS3 reports the availability of the radio resources to the radio resources management unit 12 of the RNC 10, responding to the demand (1).

The radio resource management unit 12 reports the information about the availability of the radio resources in each of the reported radio base stations BS1, BS2, and BS3 to each of the serving mobile stations, e.g., the mobile stations MS1 and MS2 through the radio base stations BS1 and BS2 (2).

Each of the mobile stations MS1 and MS2 measures the receiving electric field intensity from radio base stations that are adjacent to the radio base stations BS1 and BS2, respectively, under current communication. And based on the availability of the radio resources in the radio base stations which are adjacent to the radio base station under current communication notified as mentioned above, and the measured receiving electric field intensity mentioned above, each of the mobile stations MS1 and MS2 calculates the evaluation point that indicates the degree of the suitability of each radio base station for a communicating counterpart to the mobile station concerned, like the example mentioned above (3). The calculation method is the same as the method mentioned in the fifth example mentioned above (a function of the mobile station management

unit 19). Each of the mobile stations MS1 and MS2 further creates a management table as shown in Fig. 16 that describes the evaluation points for the combinations of the mobile station concerned and each of the radio base stations which are calculated as mentioned above (4).

A notice to each of the mobile stations MS1 and MS2 of the information about the available radio resources in each above-mentioned radio base station is made at an every predetermined interval. And whenever each of the mobile stations MS1 and MS2 receives the notice, it updates the evaluation point described in the management table mentioned above based on the notified information and the measured value of the receiving electric field intensity from each radio base station. If the communication traffic in a certain radio base station increases and it will be in a traffic congestion condition, the evaluation point of a mobile station which communicates with the radio base station for a combination with one or more other radio base stations becomes higher than the evaluation point of the combination with the radio base station under current communication. When the difference of those evaluation points exceeds the predetermined standard, the one or more radio base stations concerned are selected as the communicating counterpart of the mobile station concerned (3).

Then, the mobile station autonomously switches itself to the radio base station of the selected combination as the communicating counterpart as mentioned above (handover) (4). Henceforth, the mobile station communicates with

other terminals through the switched radio base station, the RNC 10, and the backbone.

In such a handover system as above, each mobile station manages the evaluation about the combination with the radio base station under current communication, and other combinations with one or more radio base stations, and each mobile station switches its communicating counterpart autonomously based on the situation managed. Accordingly, the RNC 10 does not have to manage the evaluation point of the combinations of each serving mobile station and radio base stations centrally, and the process load of the RNC 10 is mitigated.

Further, the seventh example of the handover system concerning the implementation mode of the present invention will be described. In the seventh example, each mobile station switches the radio base station as its communicating counterpart (handover) by an autonomous control based on communication conditions, similarly to the sixth example mentioned above. In this example, each mobile station chooses a radio base station as a new communicating counterpart without making a management table (referring to Fig. 16) as mentioned above.

Here a case is assumed, for example, where communication data of a mobile station which communicates with a certain radio base station increased rapidly, and the radio base station concerned turns into a traffic congestion condition.

Each mobile station processes according to the procedure shown in Fig. 18.

For example, the case where the

communication data of the mobile station MS1 which communicates with the radio base station BS1 increases rapidly, and the radio base station BS1 concerned is in traffic congestion is assumed. In this case, the mobile station MS1 compares an amount of the radio resources  $R_u$  which is newly needed for the increased amount of communication data with an amount of the available radio resources  $R_l$  in the radio base station BS1 reported from the RNC 10 as mentioned above (S1). If the result of the comparison is that the amount of the available radio resources  $R_l$  in the radio base station BS1 is larger than the amount of the radio resources  $R_u$  that is newly needed as mentioned above (YES in S1), the mobile station MS1 will maintain the communication condition with the radio base station BS1 (S2), that is, the handover of the mobile station MS1 is not made in this case.

On the other hand, if the amount  $R_l$  of the available radio resources in the above-mentioned radio base station BS1 is smaller than the radio resources amount  $R_u$  that is newly needed for the data communications by the mobile station MS1 as mentioned above (it represents NO in S1), the mobile station MS1 measures the receiving electric field intensity from the radio base stations BS2 and BS3 that are adjacent to the radio base station BS1 (S3). In addition, priority of the adjacent radio base stations is decided according to the magnitude of the receiving electric field intensity.

The mobile station MS1 first determines whether the electric field intensity from a radio base station, BS2 for example, that ranks the



highest priority (providing the highest receiving electric field intensity) is sufficient for communication (S4). If the electric field intensity is not sufficient for communication (it is NG in S4),  
5 the mobile station MS1 will maintain the communication with the radio base station BS1 (handover suspended). In this case, the radio base station BS1 assigns radio resources to the communication for the mobile station MS1 within the  
10 limit of the available radio resource R1.

On the other hand, if the electric field intensity from the radio base station BS2 is enough for communication (OK in S4), the mobile station MS1 will determine further whether an amount R2 of the  
15 available radio resources of the radio base station BS2 reported from the RNC 10 as mentioned above is larger than the amount Ru of the radio resources that is newly needed by the mobile station MS1 concerned (S5). If the amount R2 of available radio  
20 resources of this radio base station BS2 is larger than the amount Ru of the radio resources newly needed by the mobile station MS1 (YES in S5), the mobile station MS1 will nominate the radio base station BS2 as a communicating counterpart (S6). The  
25 communicating counterpart of the mobile station MS1 is switched from the radio base station BS1 to the radio base station BS2 by the switching control of the RNC 10 based on the nomination (handover is carried out).

30 Further, if the amount R2 of available radio resources of the radio base station BS2 is smaller than the amount Ru of radio resources which is newly needed by the mobile station MS1 (NO in S5),

the mobile station MS1 determines whether the total amount of available radio resources R1 and R2 of the radio base stations BS1 and BS2, respectively, (R1+R2) is larger than the amount Ru of [the radio] unrelated resources that is newly needed by the mobile station MS1 concerned (S7). If the total amount (R1+R2) is larger than the amount Ru of radio resources newly needed by the mobile station MS1 concerned (YES in S7), the mobile station MS1 nominates the two radio base stations BS1 and BS2 as the communicating counterparts (S8). The communicating counterpart of the mobile station MS1 is switched from one station of the radio base station BS1 to two stations of the radio base stations BS1 and BS2 by the switching control of the RNC 10 based on the nomination (partial handover is carried out).

On the other hand, if the total of the amounts R1 and R2 (R1+R2) of the available radio resources of the both above-mentioned radio base stations BS1 and BS2 is smaller than the amount Ru of radio resources newly needed by the mobile station MS1 concerned (NO in S7), the mobile station MS1 determines whether the electric field intensity from the radio base station BS3, for example, where the priority is high (receiving electric field intensity is high), having given the highest electric field intensity next to the radio base station BS2, gives sufficient electric field intensity for communications (S9). If the electric field intensity is not enough for communications (NG in S9), the mobile station MS1 will maintain communication with the radio base station BS1 like

an above-mentioned case (NG in S4) (handover suspended).

5 If the electric field intensity from the above-mentioned radio base station BS3 is enough for communications with the mobile station MS1 (OK in S9), the mobile station MS1 concerned will determine further whether the amount R3 of available radio resources in the radio base station BS3 reported from the RNC 10 as mentioned above is larger than  
10 the amount Ru of radio resources newly needed (S10). If the amount R3 of the available radio resources in the radio base station R3 is larger than the amount Ru of radio resources newly needed by the mobile station MS1 (YES in S10), the mobile station MS1  
15 nominates the radio base station BS3 as the communicating counterpart (S11). The communicating counterpart of the mobile station MS1 is switched from the radio base station BS1 to the radio base station BS3 by the switching control of the RNC 10  
20 based on this nomination (handover is carried out).

If, on the other hand, the amount R3 of the available radio resources of the radio base station BS3 is smaller than the newly needed amount Ru by the mobile station MS1 (NO in S10), the mobile  
25 station MS1 determines whether the total amount of R1 and R2 of the available radio resources of the radio base stations BS1 and BS3 ( $R1+R3$ ) is larger than the amount Ru of [the radio] *unrelated* resources newly needed by the mobile station MS1  
30 concerned (S12). If the total amount ( $R1+R3$ ) is larger than the amount Ru of radio resources newly needed by the mobile station MS1 concerned (YES in S12), the mobile station MS1 nominates the two radio

base stations BS1 and BS3 as the communicating counterpart (S13). The communicating counterpart of the mobile station MS1 is switched from one station of the radio base station BS1 to two stations of the radio base stations BS1 and BS3 by the switching control of the RNC 10 based on this nomination (partial handover is carried out).

If the total amount of the amounts R1 and R3 of the available radio resources of the both of the above-mentioned radio base stations BS1 and BS3 ( $R1+R3$ ) is smaller than the amount Ru of radio resources which is newly needed by the mobile station MS1 concerned (NO in S12), the mobile station MS1 determines whether a total of the amounts R2 and R3 of available radio resources of the two radio base stations BS2 and BS3 adjacent to the radio base station BS1 ( $R2+R3$ ) is larger than the amount Ru of radio resources newly needed by the mobile station MS1 concerned (S14). If the total amount ( $R2+R3$ ) is larger than the amount Ru of radio resources that is newly needed as mentioned above (YES in S14), the mobile station MS1 will nominate the two radio base stations BS2 and BS3 as the communicating counterpart (S15). The communicating counterpart of the mobile station MS1 is switched to the two stations of the radio base stations BS2 and BS3 from the radio base station BS1 by the switching control of the RNC 10 based on this nomination (handover to two or more stations).

Further, when the total amount R2 and R3 ( $R2+R3$ ) of the available radio resources of the both radio base stations BS2 and BS3 mentioned above is smaller than the amount Ru of radio resources newly

needed by the mobile station MS1 concerned (NO in S14), the mobile station MS1 determines whether a total amount of radio resources R1, R2, and R3 of three radio base stations BS1, BS2, and BS3

5 (R1+R2+R3) is larger than the amount Ru of radio  
resources which is newly needed by the mobile  
station MS1 concerned (S16). If the total amount  
(R1+R2+R3) is larger than the amount Ru of radio  
resources newly needed by the mobile station MS1  
10 concerned (YES in S16), the mobile station MS1 will  
nominate the three radio base stations BS1, BS2, and  
BS3 as the communicating counterpart (S17). The  
communicating counterpart of the mobile station MS1  
is switched from one station of the radio base  
15 station BS1 to three stations of the radio base  
stations BS1, BS2, and BS3 by the switching control  
of the RNC 10 based on this specification (partial  
handover).

If, on the other hand, there are no other adjacent radio base stations when the total amount of the radio resources ( $R_1+R_2+R_3$ ) mentioned above is smaller than the amount  $R_u$  of radio resources newly needed by the mobile station MS1 concerned (NO in S16), the mobile station MS1 will maintain communication with the radio base station BS1 like the case (NG in S4 and NG in S9) mentioned above (handover suspended).

The above process is performed by the mobile station when the amount of data communications of the mobile station which is communicating with the radio base station increases rapidly. Therefore, when a mobile station under communication enters into the communication area of

a certain radio base station, the radio base station concerned may turn into a traffic congestion condition, then it is uncertain which mobile station that is communicating with the radio base station concerned should execute the process relative to the handover according to the procedure mentioned above (refer to Fig. 18). Then, by providing the mobile station management unit 19 in the RNC 10 as mentioned above, a suitable mobile station can switch radio base stations for the communicating counterpart by autonomous control based on communication situations in the case mentioned above.

For example, when a mobile station advances into the communication area, all the mobile stations that are already in communication with the radio base station which will be in a traffic congestion condition measure the receiving electric field intensity from the radio base station concerned, and each mobile station reports the measured value to the mobile station management unit 19 of the RNC 10. The mobile station management unit 19 gives a priority in an ascending order of the reported low receiving electric field intensity of each mobile station. In addition, the mobile station management unit 19 directs to perform the handover process to the mobile station of the highest priority (receiving electric field intensity being the lowest). The directed mobile station executes the handover process according to the procedure as shown in Fig. 18. The radio resources amount  $R_u$  is equal to the amount of radio resources which the specified mobile station is presently using in this case.

5 If the amount of the radio resources made  
available by the handover of the mobile station  
mentioned above is not large enough to reach the  
amount of radio resources which is to be used by a  
mobile station which advances into the communication  
area, or the handover of the mobile station  
specified to carry out the handover as mentioned  
above was not possible, an handover direction is  
issued to a mobile station of the next priority (the  
10 receiving electric field intensity being the second  
lowest) to carry out the handover process according  
to the procedure shown in Fig. 18. In addition, the  
process for nominating a mobile station and  
executing the handover at the nominated mobile  
15 station is repeatedly performed until the amount of  
radio resources made available reaches the amount of  
radio resource to be used by the mobile station that  
advances into the communication area.

20 In the following, the eighth example of  
the handover system relative to the implementation  
mode of the present invention will be described.

In this example, verification is performed  
as to whether the communication situation at the  
mobile station which carried out the handover is  
25 suitable after the handover of the mobile station is  
carried out according to each example mentioned  
above.

The handover system concerning this  
example is structured as shown in Fig. 19.

30 In Fig. 19, the RNC 10 includes the  
electric field intensity measurement control unit 11,  
the radio resources management unit 12, the switch  
13, and the mobile station management unit 19 like

the fifth example mentioned above (refer to Fig. 10). The RNC 10, further, includes a BER (Bit Error Rate) measuring control unit 20. Each of the mobile stations MS1, MS2, and MS3 is equipped with a BER  
5 measuring instrument for measuring an error rate (BER) of an error in communication with a radio base station.

In this example, process is performed according to the procedure shown in Fig. 20.

10 If the radio base station BS2 becomes in a traffic congestion condition by the handover of the mobile station MS1 which has been communicating with the radio base station BS1, handover of the mobile station MS2 which was communicating with the radio  
15 base station BS2 which becomes in the traffic congestion condition will be carried out according to procedures similar to the procedures (a), (b), and (c) shown in Fig. 11. Consequently, the communicating counterpart of the mobile station MS2  
20 is switched from one station of the radio base station BS2 to two stations of the radio base stations BS2 and BS3.

If the communicating counterpart of the mobile station MS2 is switched to the radio base  
25 stations BS2 and BS3 in this manner, the error rate in the communication of this mobile station MS2 will be checked (refer to (d) of Fig. 20). That is, the BER measuring control unit 20 of the RNC 10 directs the mobile station MS2 via each of the radio base  
30 stations BS2 and BS3 to measure the error rate. If the mobile station MS2 receives the direction, the BER measuring instrument will measure the error rate in communication with each of the radio base



stations BS2 and BS3 according to the direction. In addition, the mobile station MS2 reports the measured error rate to the BER measuring control unit 20 of the RNC 10.

5           The BER measuring control unit 20 will determine whether the error rate is below a standard value when the error rate report is received from the mobile station MS2. If the error rate is below the standard value, a notice that the handover was  
10 carried out successfully is given to the mobile station MS2 from the BER measuring control unit 20 via the radio base stations BS2 and BS3. On the other hand, if the error rate exceeds the fixed value, the BER measuring control unit 20 directs the  
15 mobile station management unit 19 to start the procedure for selecting a combination of a mobile station for handover and the radio base station which serves as the communicating counterpart, noting that the combination of the mobile station  
20 MS1 and the radio base station which serves as the communicating counterpart is unsuitable. Then, selection of a combination of the mobile station which should carry out handover and the radio base station as the handover destination according to the  
25 procedure (refer to Fig. 12) mentioned above is made again under the control of the mobile station management unit 19. In addition, the handover is carried out for the selected mobile station to the radio base station that is paired therewith.

30           When the handover process of a mobile station which was communicating with the radio base station BS2 to an adjacent radio base station is performed and a check result of the communication

after the handover is proper as described above, the handover of the mobile station MS1 from the radio base station BS1 to the radio base station BS2 resumes (refer to (e) of Fig. 20)

5           As described above, according to the present invention, the handover of a mobile station can be carried out to other radio base stations where traffic is not congested when a certain radio base station is experiencing a traffic congestion, thereby enabling to provide an effective use of  
10 radio resources in the whole mobile communications network. Further, since the minimum data-transmission capacity or the minimum throughput of a user request can be secured, it becomes possible to  
15 enhance user conveniences.